VCE Chemistry 2023

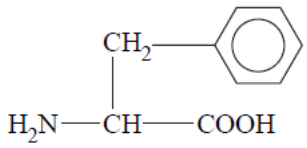
Unit 3 & 4 Trial Examination

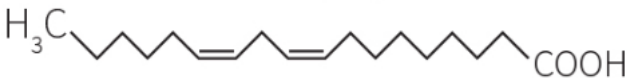
Assessment Guide

Multiple Choice Answer Sheet & Suggested Solutions

These solutions are provided as a guide and are our suggestions only.
Some questions may have alternative solution pathways which are also valid but are not shown.

Section A: Multiple Choice Answers

Question number	Correct response	Explanation
1	**B**	Refer to data book – 
2	**B**	HPLC can be used for quantitative analysis.
3	**A**	Count C from RHS using the function group -COOH.
4	**C**	Ester and water, therefore 2 products are formed.
5	**D**	Refer to data book for COOH C NMR data.
6	**B**	OH takes priority over NH2, therefore C numbering starts from the C attached to the hydroxy.
7	**C**	Other 3 are from fossil fuels, farm waste would most likely constitute organic waste – hence biological origin.
8	**C**	Cellulose cannot be digested, so is the lowest. Amylose is less soluble and more difficult to digest compared to amylopectin. Amylopectin is a branched chain polysaccharide that releases glucose readily compared to the straight chained amylose. Hence it has the highest GI index of the 3 options provided.
9	**B**	2X 24/100(13x37+4.1x17+35.3x16) = 535.4kJ

10	**A**	Rice 1.15x3.6x17=70.38kJ tacos 0.24x4.1x17=16.7kJ Therefore, Rice does provide 3 times more energy per serve compared to tacos with reference to the total energy available within the protein present.
11	**C**	Ethyl ethanoate has only 4 carbons present.
12	**A**	***Refer to databook*** **-** $CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$ 
13	**B**	Using Pv=nRT n(butanol) = 3.2/74 = 0.0432mol T = 120+273 = 403K, P=120kPa V(CO2) = nRT/P = 0.0432x8.31x403/120 = 1.21L
14	**D**	As 2 mol of butanol burnt, energy per mol = 2880kJ (*databook) As energy is released from its combustion… the reaction is exothermic. Therefore delta H is -5760 kJ mol^{-1}
15	**C**	Secondary Structures = pleating/helix formations, are caused by hydrogen bonding between parts of the protein chain.
16	**A**	Some redox titrations don't need indicator as the change in oxidation state of products can form coloured ions.
17	**D**	All 3 add to 29, not enough info to rule any of them out.
18	**B**	Fragmentation is caused by electrons knocking off other e- within the sample producing positive ions. Addition of e- would form negative ions.
19	**D**	Definition of a dependent variable
20	**C**	The question is referring to structure, IR provides information regarding potential functional groups present based on bonding relationships. option A *empirical formula = simplest whole number ratio of atoms in a molecule – does not give insight to structure B – proton NMR is **not** used for carbon environments. D – MR is **not** used for mass determination
21	**B**	Rf = 1.5/4=0.375
22	**D**	Has lower particulates than petrol
23	**A**	Refer to data booklet, the range 205-220 *KETONE, $R_2C{=}O$

24	**B**	1.1x36.1 = 39.71 kJ, 39710x0.4(60% lost) = 15884J transferred to water 15884 = 100x4.18x(70.5-Ti)
25	**C**	Esterification reaction produces water
26	**B**	Addition of ascorbic acid helps prevent food spoilage from oxidation
27	**D**	0.8 – (- 0.44) (refer to data booklet)
28	**D**	The reaction should work as described - if no value, it's not connected properly!
29	**C**	Only pair with S in both - *process of elimination.
30	**C**	Q= It, 8 x 3x60x60 = 86400C n(e-)=Q/F, 86400/96500 = 0.895mol n(Cu)=1/2 x n(e-) = 0.446mol mass(Cu)=n x M, 0.446 x 63.5 = 28.4g

END OF SECTION A

Section B – Short Answer Questions

Instructions for Section B

Answer **all** questions in the spaces provided but if more space is needed, use the additional working space at the end and clearly label your answer.

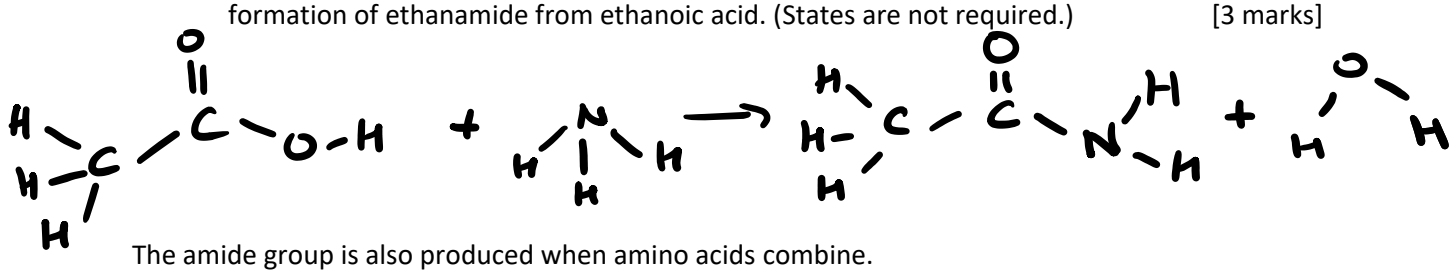
Write using blue or black pen. No white out.

To obtain full marks you should:

- Give simplified answers, with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks
- Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working
- Make sure chemical equations are balanced and that the formulas for individual substances include indication of state; for example; e.g. $H_{2(g)}$, $NaCl_{(s)}$
- Unless otherwise indicated, the diagrams in this exam are **not** drawn to scale.

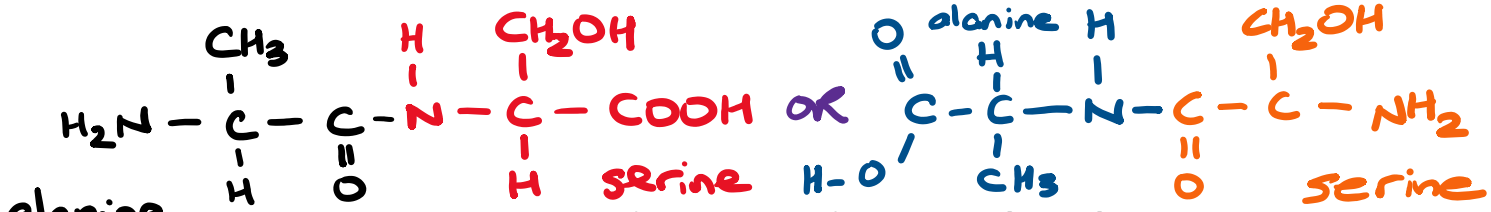
Question 1 (9 marks)

a) Using structural formulae for all reactants and products, write a balanced equation for the formation of ethanamide from ethanoic acid. (States are not required.) [3 marks]



The amide group is also produced when amino acids combine.

b) i. Draw the two possible isomers when alanine and serine form a dipeptide. [2 marks]



ii. How many chiral centres are found in either of the isomers? [1 mark]

2

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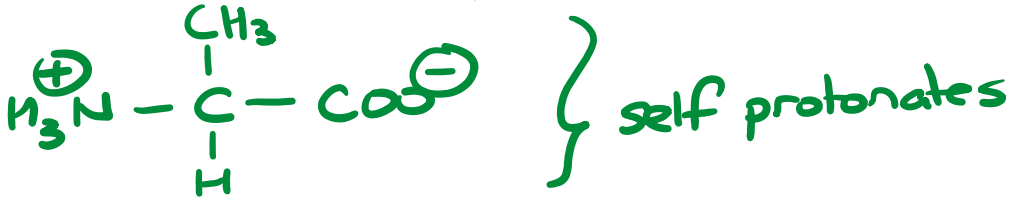
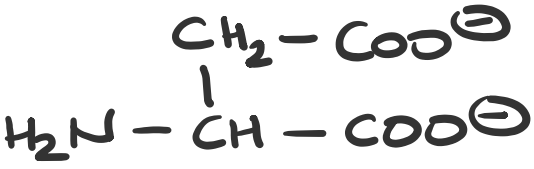
c) i. Draw a Zwitterion of alanine in an intermediate pH environment. [1 mark]

↳ pH = 7



ii. Draw the structure of aspartic acid in a high pH environment. [2 marks]

↳ Basic environment



Question 2 (5 marks)

Propane is used in domestic gas bottles commonly found attached to a backyard BBQ. An environmentally conscious family want to calculate how much CO_2 they are producing each time they cook a meal on their BBQ. They weigh a gas bottle before they start cooking and it is 3.27kg. After the cooking is finished, they reweigh the bottle and find that it now weighs 3.04kg.

a) Write the balanced thermochemical equation for the complete combustion of propane. [2 marks]

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H - 2220kJ/mol$

1 mark for ΔH and 1 mark for states, must be $H_2O(l)$, as ΔH is determined at SLC.

b) What volume, in L, of CO_2 will be produced if the air temperature is 30 °C, and the air pressure is 101.7 kPa? [3 marks]

Vol(CO_2) = ? Using Pv = nRT… V = nRT/P *T – 30 + 273 = 303K

mass(propane) = 3.27-3.04 = 0.23kg (230g)

n(propane) = m/M = 230/44 = 5.23mol

n(CO_2) = 3 x n(propane), 3 x 5.23mol = 15.68mol

Vol(CO_2) = 15.68 x 8.31 x 303/101.7 = 388.25L, sig figs = 3.9×10^2L

Question 3 (9 marks)

Climate change is affecting the balance of carbonate ions, $CO_3^{2-}{}_{(aq)}$, in the ocean. Shellfish and sea snails use the carbonate ions, in the form of calcium carbonate, to build their protective exoskeleton.

The process of making carbonate ions involves $CO_{2(g)}$ from the atmosphere dissolving in water, forming a hydrogen carbonate ion and then the carbonate ion; each step in the process is an equilibrium reaction.

The final step is written below:

$CO_3^{2-}{}_{(aq)} + H_3O^+{}_{(aq)} \longleftrightarrow HCO_3^-{}_{(aq)} + H_2O_{(l)}$

a) Write an expression for the equilibrium constant involving only the aqueous ions. [1 mark]

$K_c = [HCO_3^-]/[CO_3^{2-}][H_3O^+]$

A group of scientists have decided to model this process to better understand how to protect marine invertebrates.

In the laboratory, under standard laboratory conditions (SLC), hydrogen carbonate ions, in the form of solid potassium hydrogen carbonate, were put in a fish tank containing 20L of deionised water. Initially 20.0g of $KHCO_3$ was placed in the tank. The next day, the scientists measured the concentration of carbonate ions and found that it was 0.0034M. They decided not to start their calculations. The following day, the concentration of carbonate ions was retested, and again the concentration was 0.0034M.

b) Why did the scientists measure the carbonate concentration two days in a row? [1 mark]

To ensure the system has reached equilibrium.

c) i. Calculate the value of K_c at 25°C. [3 marks]

n(HCO3) 20/100.1 = 0.1998

	HCO_3^-	CO_3^{2-}	H_3O^+
Initial (mol)	0.1998	0	0
Change	- 0.068	+ 0.068 *(1 mark)*	+0.068
End (mol)	0.1318	0.068mol	0.068
Equilibrium con'n (M)	0.00659M *(1 mark)*	0.0034M	0.0034M

Kc = [HCO3-]/[CO32-][H3O+]

$= 0.00659/(0.0034)^2 = 570.069$

$= 570\ M^{-1}$ *(1) answer (2 s.f.)*

ii. State the unit for the equilibrium constant. [1 mark]

M^{-1}

d) What is the pH in the fish tank at equilibrium? [1 mark]

pH = -log[H3O+] = - log(0.0034) = 2.468 ~ 2.5 (2 s.f.)

A literature research by the scientists has found that the pH of the ocean is 8.1. They decide that they want the equilibrium pH to also be 8.1. To increase the pH in the tank, it is decided to add sodium hydroxide (NaOH).

e) With reference to Le Châtelier's principle, describe what will happen to the carbonate ion concentration as a result of adding the sodium hydroxide. [2 marks]

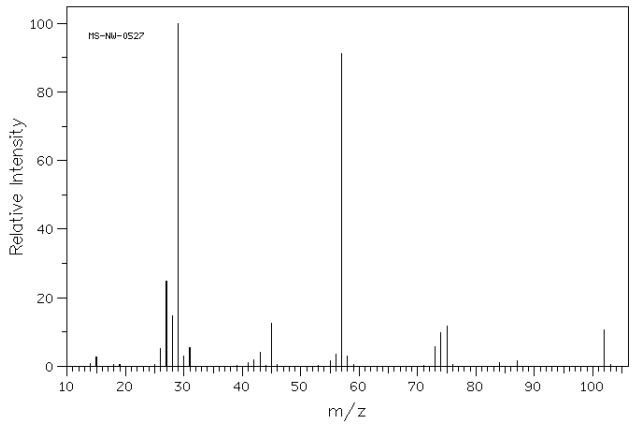
When the NaOH is added it will react with the H_3O+ and thus the H_3O+ concentration will decrease. (1 mark)

The system will try to oppose this change by moving to the left/reverse reaction. This will increase the CO_3^{2-} ion concentration. (1 mark)

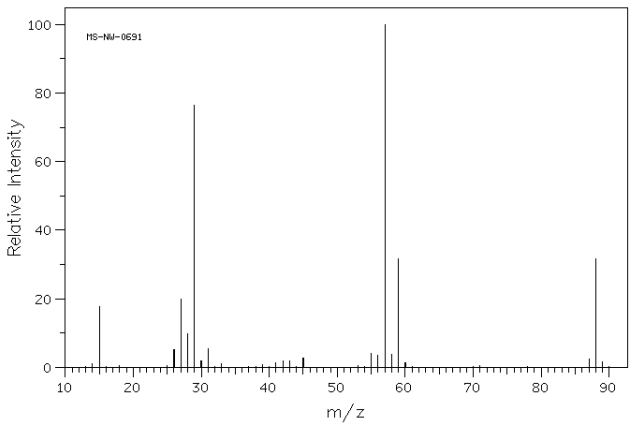
Question 4 (6 marks)

The two mass spectra below represent two esters as labelled.

Ethyl propanoate



Methyl propanoate



Data: SDBS web http://sdbs.db.aist.go.jp

National Institute of Advanced Industrial Science and Technology

a) What is the base peak for ethyl propanoate? [1 mark]

29

There are a number of similarities and differences between the two spectra.

b) Explain why they both have strong peaks at 29 and 57. [2 marks]

Both molecules will form similar fragments as they have as structures. *(1 mark)*

29 is likely to be caused by $CH_3CH_2^+$, the 57 is likely to be caused by $CH_3CH_2CO^+$ *(1 mark)*

c) What is the most likely fragment represented by the peak at 15? [1 mark]

CH_3+

d) Why is the peak at 15 for methyl propanoate much higher than the peak at 15 for ethyl propanoate? [2 marks]

Fragmentation of the CH_3^+ ion is a more likely given the origin ester is methyl propanoate. Whereas ethyl propanoate will show create a strong peak at 29 due to CH_3CH_2+ forming.

Question 5 (12 marks)

People who suffer from Gastroesophageal reflux disease (GERD) are often placed on special diets to treat the condition.

The GERD diet suggests multigrain bread, which is low GI, instead of white bread, which is high GI.

a) What does GI stand for? [1 mark]

Glycaemic Index

b) During digestion, starch breaks down to what smaller molecules? [1 mark]

Glucose

Another part of the GERD diet is to reduce dairy intake. Lactose is a sugar found in milk.

c) i. Lactose intolerance is caused by a lack of what protein? [1 mark]

The Lactase enzyme.

ii. What could a lactose intolerant person do to help them digest lactose? [1 mark]

Ingest lactase.

Another part of the GERD diet is a low-fat intake.

d) What is the basic difference between fats and oils? [2 marks]

Fats are solids at room temperature, whilst oils are in the liquid state.

The World Health Organisation (WHO) states that "Industrial trans fats are not part of a healthy diet". Trans-fat is often found in fast foods, snack foods and fried foods.

e) Explain how the structure of a monounsaturated trans-fat potentially leads to more health issues compared to the naturally occurring cis fat isomer. [2 marks]

The trans isomer will be linear and will pack tightly together, making it harder for the body to break it down. *(1 mark)* The cis isomer has a kink in it and therefore will not pack as tightly, making it easier to break down. *(1 mark)*

The GERD diet does allow for fish to be eaten. It is known that fish has a high level of omega-3 and omega-6 fatty acids

f) i. What is the difference between omega-3 and omega-6 fatty acids? [1 mark]

Omega 3 fatty acids contain their first c=c (double bond) at the 3rd carbon from the end, whilst the Omega 6 fatty acid has its first c=c (double) at the 6th carbon from the end.

ii. What makes these fats, more easily digested than a saturated fat like stearic acid, found in beef? [3 marks]

Naturally occurring unsaturated fats have kinks in their fatty acid chains due to the presence of c=c bonds. *(1 mark)*

These kinks reduce the strength of intermolecular forces between molecules due to poorer packaging compared to saturated fats. *(1 mark)*

As a result these molecules exist further apart and require less energy to separate and break apart. *(1 mark)*

*The kinks in their structure reduce steric hindrance for enzyme action as well.

Question 6 (8 marks)

Lentils are a source of protein.

Proteins are broken down into amino acids and then moved around the body in the bloodstream to the places that they are needed for growth and repair of tissue and other functions

a) Describe the process of breaking down protein to form amino acids. In your response, start with the cooked lentil in the mouth and finish with the absorption of amino acids into the blood stream in the small intestine. [4 marks]

Mechanical digestion (chewing starts) breaks the lentils into smaller pieces, increasing their surface area. *(1 mark)*

A small amount of the tertiary structure will also be broken down in the mouth while chewing.The low pH environment of the stomach will further disrupt the tertiary structure of proteins. *(1 mark)*The enzyme pepsin, found in the stomach, breaks the long polypeptides into shorter polypeptides. *(1 mark)*

As the shorter polypeptides move through the duodenum, and into the intestine, they are broken down further into shorter chains until individual amino acids are transferred to the bloodstream. *(1 mark)*

b) Enzymes form an essential part of the digestion of macromolecules is the body. Discuss the effects that lowering, and raising, the body's core temperature has on enzymes. In your response, refer to what happens to the enzymes once the body's temperature returns to normal. [4 marks]

Increased temperatures denature the tertiary structure of enzymes. *(1 mark)*
When the body temp returns to normal, denatured enzymes do not return to the original shape and so no longer function. *(1 mark)*
At decreased temperatures, enzyme action reduces significantly due to insufficient energy ($<E_A$) for a successful reaction. *(1 mark)*
When the body returns to its normal temperature, enzymes will work again, because they have not lost their shape. *(1 mark)*

Question 7 (11 marks)

Enzymes are biological catalysts speed up the rate of reaction. All amino acids, except glycine are chiral. When molecules and optical isomers react with assistance from an enzyme, only one enantiomer forms an enzyme-substrate complex in the active site. At the start of the twentieth century, scientists understood enzyme action via the "Lock and Key" model. At the start of the twenty first century, scientists understand enzyme action via the "Induced fit" model.

a) Define the following terms: [4 marks]

i. Chiral

A chiral molecule is one that is not superimposable on its mirror image and does not have a plane of symmetry. *(1 mark)*

ii. Enantiomer

Enantiomers are a pair of molecules that are the mirror image of each one another but cannot be superimposed on each other as they are optical isomers. *(1 mark)*

iii. Enzyme-substrate complex

An enzyme-substrate complex is an intermediate molecule formed when the enzyme and substrate combine. *(1 mark)*

iv. Active site

The active site refers to the specific part of an enzyme's structure where a substrate can bind and undergo a catalytic reaction. *(1 mark)*

b) What are the similarities and differences between the "Lock and key" model and the "Induced fit" model. [4 marks]

<u>Similarities</u>:

Both have a substrate fitting into the active site. *(1 mark)*

Only one substrate fits a particular enzyme, *enzymes are specific. *(1 mark)*

<u>Differences</u>:

The 'lock and key' model describes the enzyme-substrate complex as a rigid combination that does not change shape. *(1 mark)*

The induced fit model describes the enzyme-substrate complex as a conforming combination whereby the enzyme's active site moulds itself to fit the substrate. *(1 mark)*

One of the many uses of Vitamin C in the human body is as a coenzyme.

c) Describe the role of coenzymes in activating a previously inactive enzyme. A diagram may be helpful, but is not necessary to gain full marks. [3 marks]

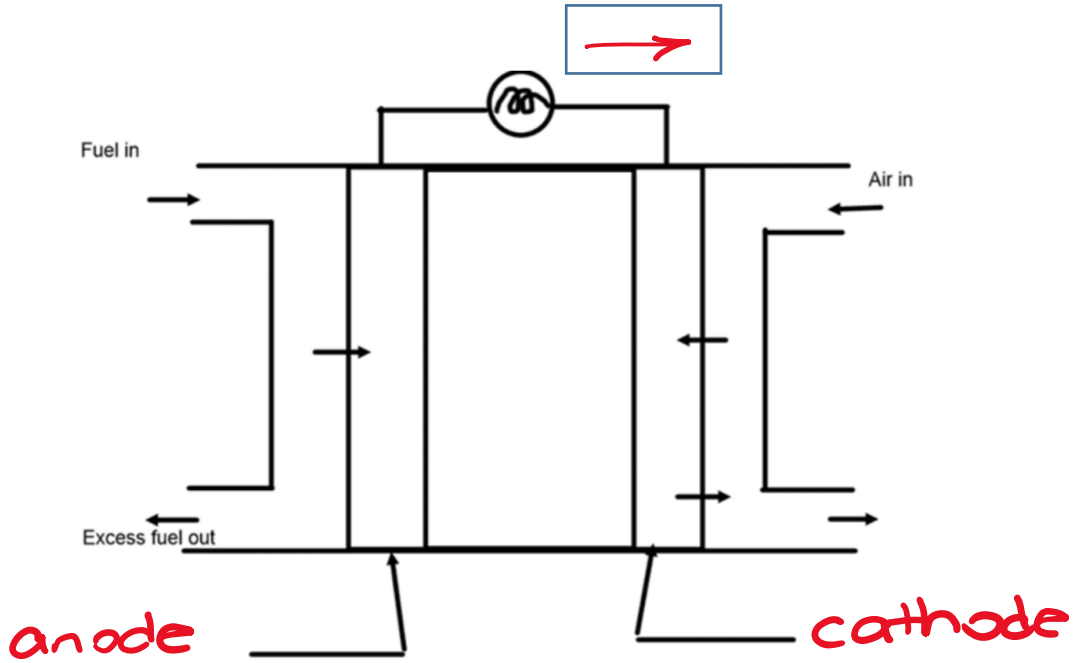
A coenzyme is a small molecule (relative to the enzyme).
They have the capacity to -
Change the surface shape *(1 mark)*
Act as carriers of electrons of a specific group of atoms *(1 mark)*
Allow the enzyme to better bind with the substrate at the active site *(1 mark)*

Question 8 (7 marks)

As a way to help tackle climate change, researchers have been investigating using ascorbic acid (AA), commonly known as vitamin C, as a fuel source in a new fuel cell. AA is oxidised to dehydroascorbic acid (DHA) $C_6H_6O_6$. Whilst this type of cell is called a Direct Liquid Fuel Cell (DLFC), the researchers have been trialling various gels to carry the AA into the cell. The cell uses an acid as the electrolyte and oxygen, from the air, is converted to water.

a) Write the half equation for the oxidation of AA to DHA. (No need to include states.) [2 marks]

$C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e^-$



b) Label the anode and the cathode on the lines above. [1 mark]

c) In the box above, draw an arrow to indicate the direction of the electron flow. [1 mark]

d) What is the reductant in this cell? [1 mark]

Ascorbic Acid

e) Write the overall reaction for the fuel cell. (No need to include states.) [2 marks]

$2C_6H_8O_6 + O_2 \rightarrow 2C_6H_6O_6 + 2H_2O$

Question 9 (7 marks)

In recent years there has been a push by governments for households to monitor and check old gas heaters. Old heaters can become inefficient, wasting money for the home owner, but more importantly, they can become dangerous if they start producing carbon monoxide.

a) Write a balanced equation for the incomplete combustion of methane, where carbon monoxide is the only carbon based-product. [1 mark]

$2CH_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{(g)} + 4H_2O_{(g)}$ *accept water as (l)

The heat of combustion of methane when CO is produced, is 556 kJ/mol. An old gas heater in a particular home is checked and it is determined that only 80% of the methane is converted to CO_2 and 20% is converted to CO.

a) If 2000g of gas is used (assume it is 100% methane), what is the total energy produced, in MJ, by the heater that is operating at 80% complete combustion. [3 marks]

$n(CH_4) = 2000/16 = 125mol$ *(1 mark)*

If 80% of methane undergoes complete combustion,

0.8x125mol = 100mol

Data booklet – methane yields 890kJ/mol

Then 100mol of methane releases

100mol x 890kJ = 89000kJ *(1 mark)*

While the incomplete combustion of methane yields 556kJ/mol

25mol x 556kJ = 13900 kJ

Total energy is 102,900 kJ = 103 MJ (3 s.f.) *(1 mark)*

If a person suffers from carbon monoxide poisoning, the treatment is to give pure oxygen.

a) Discuss how this treatment removes carbon monoxide. In your response, refer to the competing equilibria between the formation of carboxyhaemoglobin and oxyhaemoglobin. [3 marks]

Haemoglobin + oxygen ←→ oxyhaeoglobin

Haemoglobin + carbon monoxide ←→ carboxyhaeoglobin

Kc for second reaction is 20000 times greater than first.

By providing excess oxygen, the system will try to oppose that change and the first reaction moves to the right. *(1 mark)*

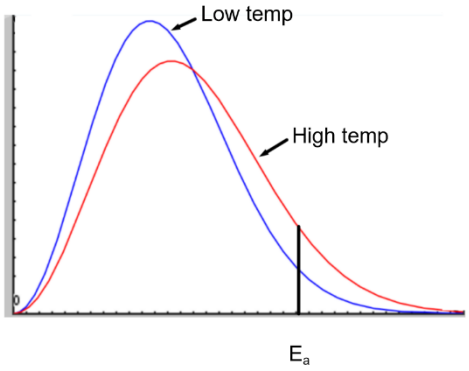
As the amount of haemoglobin decreases, the second reaction will try to oppose this change and moves left. *(1 mark)*

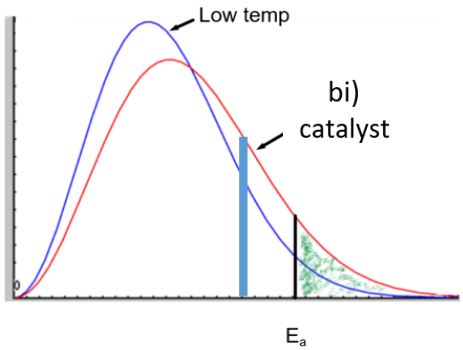
This releases carbon monoxide from the lungs. As the concentration of CO reduces from the body, the second reaction will continue to move to the left to oppose that change. *(1 mark)*

Teacher discretion can be used with allocation of these marks.

Question 10 (7 marks)

Ethene and hydrogen have a relatively slow reaction rate at SLC. On the Maxwell-Boltzmann distribution below, this is represented by the *Low temp* line. The reaction rate increases when the gases are heated to 400K, represented by the *High temp* line.





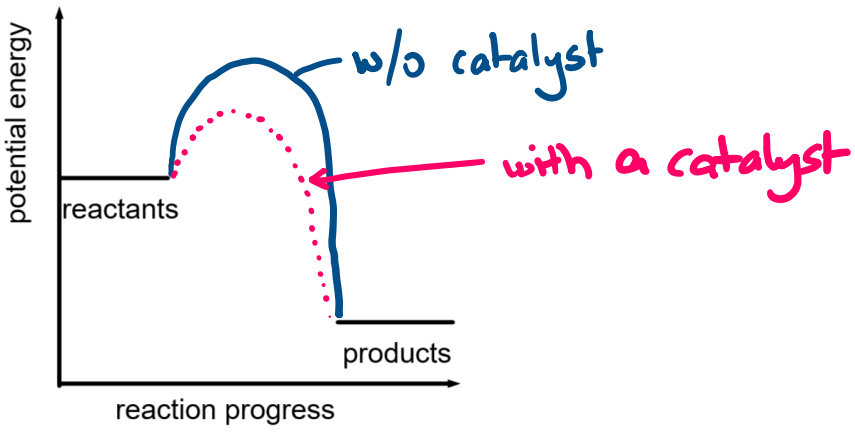
a) Use collision theory to explain why the rate of reaction increases at the higher temperature. In your answer refer to the Maxwell-Boltzmann distribution and include shading at least one area. [4 marks]

As the temperature increases, particles have an increase in their average kinetic energy. *(1 mark)*
This results in more frequent collisions. *(1 mark)*
It also means that a higher proportion of collisions will have energy over the Ea. *(1 mark)*
This can be seen on the graph as the green shaded area. *(1 mark)*

b) By using a platinum catalyst, the low temp reaction will occur much quicker.

i. Indicate on the diagram above, the change to the activation energy that occurs when a catalyst is used. [1 mark]

ii. Indicate on the energy profile diagram below the effect the catalyst has. Draw and label the energy profile both with, and without, a catalyst. [2 marks]



Question 11 (9 marks)

Two year 12 students decided to investigate if the presence of a double bond in a molecule changed the heat of combustion. They decided to use cyclohexane and cyclohexene to test their hypothesis that,

"The presence of a double bond in a hydrocarbon will result in a higher heat of combustion"

They used the following method:

Method

1. Set up according to model.
2. Fill a can with 100ml of water, record initial temperature.
3. Weigh spirit burner containing fuel, record mass.
4. Light spirit burner to heat water, Stir continuously.
5. Once temperature has risen 6 - 7°C, extinguish flame and record the highest temperature reached by the water.
6. Repeat for the second fuel.

The following are extracts from their Discussion and Conclusion

The results of the experiment found that Cyclohexane had a heat of combustion of 14kJ/mol and that Cyclohexene had a heat of combustion of 240kJ/mol. This shows that Cyclohexene has a much higher heat of combustion than that of Cyclohexane. This suggests that the presence of a double bond results in a higher heat of combustion.

Limitations of this experiment include: the assumption that all energy released from the combustion of a fuel was transferred into thermal energy in the water was not scientifically accurate – some energy was more likely lost into surroundings. This means the calculated heat of combustion would have been lower than in reality. However, as this experiment was used to compare the energy content *differences* between each fuel, the heat loss was not all that relevant, as this does not change the relative *difference* in energy transferred to water.

Possible errors may have occurred in the measuring of the volume of the water and the measuring of the mass of the fuel, with inaccuracies in the scales and measuring cylinder.

Some additional notes about the student's report.

- There is no mention of the accepted values of Heat of Combustions from other experiments. These are listed below:
  - Cyclohexane -3920 kJ/mol
  - Cyclohexene -3800 kJ/mol
- There were no sample calculations given
- Only one experiment per fuel was carried out, as per the method

a) i. Identify the independent variable for this investigation. [1 mark]

Carbon to carbon double bonds present in fuel.

ii. Identify one control variable [1 mark]

Volume of water, spirit burner, equipment set up. *potentially other valid options.

b) Rewrite the students' hypothesis using the *If…….. then…….. because……..* model [3 marks]

If ***a double bond is present in a fuel (*cyclohexene) as opposed to being saturated (cyclohexane)***, then ***there should be a corresponding increase in the heat of combustion of this fuel*** because ***carbon to carbon double bonds release more energy when broken compared to single carbon to carbon bonds***.

1 mark for each correct statement.

NB: this is a rewriting of the students' hypothesis in the correct format, it is not expected that the answer be a rewrite to correct the understanding of the students in the question.

c) The *Conclusion* mentions two possible errors in the final sentence. Classify the type of each error that was suggested. [2 marks]

i. Scales:

Systematic error.

ii. Measuring cylinder:

Parallax or random error when reading the scale.

d) Give an example of a parallax error that applies to this investigation. [1 mark]

Not having an eye level with the meniscus when reading the volume off the measuring cylinder.

e) Without changing the method, list one thing the students could have done that would give more credibility to their results. [1 mark]

To improve validity, the experiment could have been performed repeatedly.

END OF SUGGESTED SOLUTIONS

